(51) Int. Cl.^{2}: **F 16 J 1-16**

FEDERAL REPUBLIC OF GERMANY
GERMAN PATENT OFFICE

(11) **Published specification 23 33 031**

(21) File no.: P 23 33 031.6-12
(22) Application date: 29.6.73
(43) Publication date (unexamined): 16.1.75
(44) Publication date (examined): 2.10.75

(54) Title: Piston pin for fluid-cooled pistons

(71) Applicant: J. Wizemann & Co., 7000 Stuttgart

(72) Inventor: Kurt Wizemann, 7000 Stuttgart; Manfred Pfiz, 7302 Nellingen

Claims:

1. A piston pin for fluid-cooled pistons, having at least one longitudinal bore, which is closed at its ends by cup-shaped closing elements pressed or shrunk therein and comprising a base and a circumferential surface, characterised in that the wall thickness of the base (30b) of the cup-shaped closing elements (30) amounts to approximately 60% of the wall thickness of the closing element circumferential surface (30a) and the latter amounts to approximately 1/10 to 1/8 of the wall thickness of the piston pin (12) around the longitudinal bore (20) and in that the wall of the longitudinal bore (20) comprises a circumferential channel (32) in the area of the end of the closing element circumferential surface (30a) in the vicinity of the base (30b) of a closing element (30).

2. A piston pin according to claim 1, characterised in that the diameter of the closing elements (30) in the unfitted state is so much greater than the diameter of the longitudinal bore (20) that deformation of the fitted closing elements remains below the yield strength of the material thereof, wherein the diameter of the unfitted closing elements is greater than the diameter of the longitudinal bore (20) in particular by 0.02 to 0.06 mm.

3. A piston pin according to one or more of the preceding claims, characterised in that the circumferential surface (30a) of the closing elements (30) and the wall of the longitudinal bore (20) have a surface quality corresponding to a ground surface.

4. A piston pin according to one or more of the preceding claims, characterised in that the closing elements (30) consist of a material with a high yield strength and in particular are extruded.

The invention relates to a piston pin for fluid-cooled pistons, having at least one longitudinal bore, which is closed at its ends by cup-shaped closing elements pressed or shrunk therein and comprising a base and a circumferential surface.

In internal combustion engines subject to severe thermal loads, the pistons are frequently fluid-cooled, in particular using the lubricating oil. This flows from a bore in the crankshaft through the connecting rod and ducts in the piston pin to the piston, where it takes up heat in a cavity in the piston head. The oil flows from there freely back into the crankcase.

An extremely wide range of types of piston pin is already known for fluid-cooled pistons, for instance, inter alia, a piston with a central and a plurality of eccentric longitudinal bores, wherein only the latter are used to supply the coolant. These eccentric longitudinal bores are closed at their ends by threaded plugs. There are two disadvantages to this: the eccentric longitudinal bores weaken the piston pin to a relatively high degree, such that piston pin breakages are not uncommon. Moreover, the oval deformation of the piston pin on ignition at the top dead centre of the piston results in the threaded plugs working free in the longitudinal bores, since these solid plugs cannot follow the oval deformation of the piston pin provided with the longitudinal bores during operation.

A second known design provides a relatively thin-walled tube in a central longitudinal bore in the piston pin, which tube has a flange sealing the longitudinal bore at each end. The known design has the disadvantage that it is not only relatively costly, but also oscillations arising during operation frequently result in cross-breaks

in the tube inserted into the piston pin. Of even more complicated design is a third known piston pin (DT-PS 13 01 677) with a central longitudinal bore, in which, however, it is not the latter which serves as a passage for the cooling oil but rather a longitudinal bore in a separate, eccentric threaded bolt, which is let into the circumferential area of the piston pin and also into the connecting rod and into two bushings surrounding the piston pin. The longitudinal bore in this threaded bolt is closed at its ends by solid plugs, which, as explained above, are likewise liable to work free.

Finally, a piston pin has become known (GB-PS 10 58 360) with a central longitudinal bore, closed at both ends, as a passage for the cooling oil, wherein slightly curved, flat disks are provided which are clearly pressed into the piston pin longitudinal bore as closing elements therefor. Although the thickness of these disks amounts to only approximately 25% of the wall thickness of the piston pin, they are likely, despite their curvature, to be much too rigid in the radial direction to be able to undergo the oval deformation of the piston pin to a sufficient degree on ignition at top dead centre, since the degree of radial rigidity has to be viewed in relation to the high specific surface pressure between the edge of the disks and the wall of the piston pin longitudinal bore, and such high specific surface pressure is unavoidable due to the disk shape of the known closing elements. The consequence is that such closing elements work free after a relatively short operating time and are even more quickly unable to offer an adequate seal. This is probably the reason why such disk-shaped closing elements, standardised to DIN 470, have in practice never been used in piston pins, but rather have been used solely to close core holes in the crankcases of internal combustion engines.

Finally, a piston pin has also become known for non-fluid-cooled pistons (DT-PS 6 89 837) which comprises a central longitudinal bore, in the ends of which are seated mushroom-shaped elements with outward-facing caps. However, these mushroom-shaped elements do not seal the piston pin longitudinal bore, since they comprise an opening in the cap, and furthermore securing of these mushroom-shaped elements in the piston pin is of no significance, since their task is to hold the piston pin in a predetermined position in the cylinder; they thus act as spacers and lie with their outwardly crowned caps against the cylinder wall. Since, moreover, the wall thickness of the caps of the mushroom-shaped elements is approximately of the order of the piston pin wall thickness, such mushrooms would also be sure to work free during operation, if they were pressed into a piston pin longitudinal bore to seal it.

For experiments with piston pins of the above-mentioned type, caps standardised to DIN 443 exhibiting the same wall thickness throughout were initially used as closing elements. These cup-shaped closing elements were secured in the piston pin longitudinal bore by means of a bead rolled into their outer circumferential surface; in operation, however, it became clear that this type of securing is extremely problematic and it cannot be ruled out that the closing elements might work free during operation or no longer lead to pressure-tight closure of the piston pin longitudinal bore. Therefore, it was essential additionally to introduce a metal adhesive into the channel in the piston pin longitudinal bore corresponding to the bead on the closing element circumferential surface and finally the measure was also taken to subject the cup-shaped closing elements to complex heat treatment.

The problem on which the invention is based is therefore that of further developing these piston pins of the above-mentioned type, which have already been tested experimentally, so as cheaply to provide a permanent fit for the closing elements in the piston pin longitudinal bore.

In solving this problem, the inventor used the basic idea that the cause of the failures of the previous experiments must have been that, due to the thin wall thickness of the cup-shaped caps used as closing elements, said caps cannot absorb or are not capable of applying the forces necessary for a permanent pressure-tight interference or shrinkage fit. It was therefore a question on the one hand of making the closing elements of such a rigidity that they are able to absorb or apply the necessary forces, while on the other hand they do not work free by themselves in the piston pin longitudinal bore as a result of the oval deformation of the piston pin occurring during operation and of the hydraulic pressure surges acting on the closing elements.

According to the invention, the problem posed may be solved in that the wall thickness of the base of the cup-shaped closing elements amounts to approximately 60% of the wall thickness of the closing element circumferential surface and the latter amounts to approximately 1/10 to 1/8 of the wall thickness of the piston pin around the longitudinal bore and in that the wall of the longitudinal bore comprises a circumferential channel in the area of the end of the closing element circumferential surface in the vicinity of the base of a closing element.

The closing element circumferential surface prevents high specific surface pressures, such as would occur if flat disks were used; nonetheless, however, the forces necessary for a permanent fit may be applied, since the wall thickness of the closing element circumferential surface may be relatively large. Nonetheless, the closing elements according to the invention may adapt to the oval deformation of the piston pin occurring during operation, since their base exhibits a significantly smaller wall thickness and therefore results in relatively low rigidity in the radial direction. In order to rule out any negative effects of the radial rigidity provided by the base of the closing elements and the changes in diameter arising during operation as a result of hydraulic pressure surges, the above-mentioned channel is finally provided, which serves, so-to-speak, as a deflection space for the areas of a closing element adjoining the base during oval deformation of the piston pin. However, such a channel also brings a manufacturing advantage with it: during hardening, piston pins become not inconsiderably distorted, such that the piston pin longitudinal bore has subsequently to be ground. The channel forms a desired run-out space for the grinding wheel, such that conical run-out of the ground area of the piston pin longitudinal bore is avoided - such a conical profile would lead to compression of the inner areas of the closing elements on pressing-in of the latter and thus possibly to leakages. Moreover, the inner channel wall forms a limit stop for pressing-in of the closing element, such that the latter adopts a defined position.

It is already known (OE-PS 1 86 461) to insert cup-shaped closing elements into a crank journal of a crankshaft, but this known design could not in any way lead to a solution of the problem forming the basis of the invention: a tube is secured in a longitudinal bore in the crank journal of this known crankshaft, in the ends of which tube the cup-shaped closing elements fit. These have the same wall thickness throughout, however, and are welded or soldered to the tube. The presence of the tube is a prerequisite, however, for such securing of the closing elements, since crankshafts and crank bolts are case-hardened, such that required characteristics are partially destroyed by welding or soldering. The person skilled in the area will therefore only think of using this prior art where tubes or sleeves may be inserted into the bores to be sealed, which is impossible in the case of piston pins due to the risk of cross-breaking of such tubes. In a variant of the known design, the closing elements are secured by crimping; this type of securing is ruled out in the case of closing elements for piston

pin longitudinal bores just like lock-beading, which has already been commented on above. Apart from this, crimping or lock-beading is naturally more expensive than simple pressing-in or shrinking in, by which means the closing elements according to the invention are retained. Finally, the fact that a crankshaft journal is subjected to wholly different stresses from a piston pin also stood in the way of turning to this prior art when solving the problem forming the basis of the invention.

Further features of preferred embodiments of the invention are revealed by appended claims 2 to 4.

A particularly preferred embodiment of the invention will be explained below with reference to the drawings, likewise appended, in which

Fig. 1 shows a perpendicular section through the centre of a piston with a piston pin according to the invention and

Fig. 2 shows an end of the piston pin on a larger scale than Fig. 1.

Fig. 1 shows the top end of a connecting rod 10, which surrounds a piston pin 12, which has been inserted into a transverse bore 14 in a piston, designated overall as 16, and secured in this transverse bore using Seeger circlip rings 18.

The piston pin has a longitudinal bore 20, into which a central transverse bore 22 and outer transverse bores 24 open. The central transverse bore 22 is adjoined by a channel 25 and a longitudinal bore 26 in the connecting rod 10, while the other transverse bores 24 end at channels 27 and cooling oil holes 28 in the piston head 29 of the piston 16. These cooling oil holes 28 continue in a manner not shown in the piston head and lead finally to the bottom of the piston, whence the cooling oil flows out freely downwards into the crankcase.

According to the invention, the longitudinal bore 20 in the piston pin 12 is closed by two cup-shaped caps 30, which consist in particular of a material with a high yield strength and were produced by extrusion. As Fig. 2 clearly shows, each cap comprises a circumferential surface 30a and a base 30b, the wall thicknesses of which are in a ratio of, for example, 1 to 0.6. In this way, and because of the favourable grain flow in the transition area between circumferential surface and base, resulting from the extrusion process, the cap 30 may follow particularly well the oval deformation to which the piston pin is subject on ignition at the top dead centre of the piston.

In order to make the rigidity provided by the base 30b wholly ineffective in the radial direction in the area of the circumferential surface adjoining the base, the longitudinal bore 20 comprises a circumferential channel 32 for each cap, into which channel the end area of the circumferential surface 30a in the vicinity of the base may deflect on oval deformation of the piston pin.

The caps 30 are secured in the longitudinal bore 20 by Seeger circlip rings 36.

It has proven particularly expedient for the caps to be pressed into the longitudinal bore 20 with an overlap of 2/100 to 6/100 mm and for the faces forming the interference fit to be ground.

Moreover, it has been demonstrated that the caps exhibit sufficient strength and may nevertheless be deformed ovally relatively easily, if the ratio of the wall thickness of the piston pin 12 to the wall thickness of the circumferential surface 30a is between 10 and 9.

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